Study of Radionuclide Distribution around Chitradurga Mining Areas, Karnataka

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***Abstract* — Concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Granite, Copper, iron, silver and gold ore samples of Chitradurga district of Karnataka were studied in detail. The study was important because of the large scale mining of different minerals and ores in Chitradurga region. Granite, copper, iron, silver and gold ore samples were collected from different locations and analyzed for primordial radionuclides concentrations by using HPGe gamma ray spectrometer. Gamma ray spectrometry study was also performed on different types of commercially important decorative stones and colored granites. The ^{226}Ra, ^{232}Th and ^{40}K contents in different ore samples were found to vary from <0.36 - 10.2Bqkg^{-1},<0.18 - 6.4 Bqkg^{-1} and 4.2- 220.7 Bq kg^{-1}. The concentration of ^{226}Ra , ^{232}Th and ^{40}K,in granites and decorative stones were found in the range of 1.4-54.5 Bqkg^{-1}, 1.7-77.4 Bqkg^{-1} and 21.4 -631.7Bqkg^{-1} respectively. The results are presented and discussed in the light of the geological features of the region.**

Keywords **- Chitradurga, HPGe Detecting system, Primordial radionuclides, Radiation level, Minerals, Ores and Decorative stones.**

I. INTRODUCTION

Large scale mining of different types of ores has the potential to alter the prevailing radiation levels and radionuclides distributions in the surrounding environment of the mining region. Hence, studies on environmental radioactivity around the mining region are very important to assess the radiological impact due to the mining operations.

Chitradurga District is in Karnataka, India, lies between13º34′ and 15º02′ north latitude and 75º37′ and 77 º 01′ east longitudes. Many areas of this district have witnessed large scale mining operations for different types of ores, decorative stones and granite. Copper ore is extracted from acid felisitic rocks in the Jogimardi trap, south of Ingladhal. The copper ore available at Ingladhal is medium grade chalcopyrites containing 1.8% Copper, 10.55% Iron, 3.69% Sulphur, 68.23% Silica, 4.50 ppm Nickel and 4.50 ppm Cobalt. Gold occurs at Ingladhal in association with sulphides. Silver occurs at Guddadarangavvanahalli (GR Halli) as inclusions with arsenopyrite. Iron ore is found in association with manganiferous deposits at Bedarabommanahalli (BBH mines). Light gray granite which are classed under the newer granites in Mysore are available in the south western corner of the district.[(6,8)]

This paper presents the results of measurements of primordial radionuclides concentration in different types of ores, decorative stones and colored granites. No such study has been reported so far on this aspect for Chitradurga region and happens to be first of its kind in this region.

II. MATERIALS AND METHODS

The granites, minerals and decorative stone samples were collected and processed using standard procedures.[(2)] The activities of ^{226}Ra,^{232}Th and ^{40}K in granites, decorative stones and mineral ores were determined by gamma ray spectrometry employing 42% efficiency a n-type low background High Purity Germanium (HPGe) detector (CANBERRA,USA) having carbon fiber window. The detector was enclosed in a 10 cm thick graded lead shield. The resolution of the detector is 2.01 keV at 1.33 MeV. The spectrum was acquired and analysed by employing a PC based 16K Multi Channel Analyzer (DSA-1000, CANBERRA) and GENIE- 2000 software. The efficiency calibration of the detector was performed using IAEA quality assurance reference materials RGU-238, RGTh-232, RGK-40 and Soil-6 (Karunakara et al.2000). The minimum detection levels (MDL) for ^{226}Ra , ^{232}Th and ^{40}K for this detector were 0.365 , 0.188 and 1.048 Bq kg^{-1} respectively.

III. RESULTS AND DISCUSSIONS

The results of ^{226}Ra ^{232}Th and ^{40}K measurements in granites and mineral ores are presented in Table I. As expected, granites show higher concentrations of these primordial radionuclides when compared to that of mineral ores and decorative stones. The results observed in this study for granites are similar to those reported for other environs at other parts of the India, which vary in the range 20-500Bqkg^{-1}

for ^{226}Ra,<1-548.6Bqkg^{-1} for ^{232}Th and 600-1800Bqkg^{-1} for^{40}K [7,9,10]. The concentrations of primordial radionuclides in Copper ore Copper concentrate and Iron ore investigated in this study is low when compared to the values 30-80Bqkg^{-1} for ^{238}U series and 23-110Bqkg^{-1} for ^{232}Th series for copper ore and100-300Bqkg^{-1} for ^{238}U series and 150Bqkg^{-1} for ^{232}Th series for Iron ore reported in literature [4,12]. The estimation of gamma radiation dose for the population due to granites and mineral samples was estimated using the relation Dose rate (nGyh^{-1}) = $0.462C_{Ra}+0.604C_{Th}+0.0417C_K$, where, C_{Ra}, C_{Th} and C_K are the concentrations of Ra, Th and K. The dose rate was found to vary 0.5-98.3nGyh^{-1} with a mean value of 6.9nGyh^{-1}. The radium equivalent activity in granites, decorative stones and mineral ores were calculated using the relation $Ra_{eq} = (C_{Th}\times1.43) + C_{Ra} + (C_K\times0.077)$. The results of these calculations are presented in column 2 of Table II. These values range from 1.1(Gold and copper ore) to 209.4Bqkg^{-1}(Granites). The external and internal hazard indices for the samples were calculated using the relations $H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \leq 1$ and $H_{in} = C_{Ra}/185 + C_{Th}/259 + C_K/4810 \leq 1$ respectively and the results are presented in columns 4 and 3 of Table II. For the ores samples analyzed in this paper H_{ex} varies between0.003 (Gold ore) to 0.578(Granites). The H_{in} for the samples studied varies between 0.004(Gold ore) to 0.724(Granites).

The gamma activity concentration index ($I_{\gamma r}$) (representative level index) was calculated using the following relation $I_{\gamma r}= C_{Ra}/150 + C_{Th}/100 + C_K/1500$ and the values are presented in column5 of Table II.

The annual indoor and outdoor effective dose was calculated using the relations and dose coefficient given by UNSCEAR(2004) and considering a occupancy factor of 0.8 for indoor and 0.2 for outdoor. The values are presented in Table II (columns 6 and 7).The indoor dose was found to vary in the range 2.4 to 482.2 microSv and the outdoor dose varied in the range 0.6 to 120.5 microSv. The geological map of Chitradurga and the variation of concentrations of primordial radionuclides are shown in fig. 1 and fig.2 respectively.

TABLE I
CONCENTRATION OF PRIMORDIAL RADIONUCLIDES IN GRANITES, DECORATIVE STONES AND MINERAL ORES

Sample	Radioactivity concentration (Bqkg^{-1})		
	^{226}Ra	^{232}Th	^{40}K
Granite	54.5±2.8	77.4±1.6	631.7±15.1
Black Granite	25.6±1.8	42.9±1.2	491.4±12.4
Red Granite	29.4±2.1	47.2±1.3	628.8±15.5
Red Decorative	1.4±0.7	1.8±0.3	21.4±1.7
White Decorative	1.7±0.4	<0.18	95.2±2.9
Copper ore	<0.36	<0.18	7.3±1.2
Copper Concentrate	<0.36	<0.18	9.1±1.2
Iron ore	9.7±0.8	4.2±1.1	12.8±1.3
Silver ore	1.8±0.9	6.3±0.4	220.8±6.3
Gold ore	0.5±0.3	<0.18	4.2±0.9

TABLE III
RADIUM EQUIVALENT, EXTERNAL AND INTERNAL HAZARD INDICES AND ANNUAL EFFECTIVE DOSE

Sample	Ra_{eq}	H_{in}	H_{ex}	$I_{\gamma r}$	Annual effective Dose (microSv)	
					Indoor	Outdoor
Granite	209.4	0.724	0.578	1.558	482.2	120.5
Black Granite	121.3	0.406	0.337	0.927	285.5	71.3
Red Granite	134.8	0.472	0.392	1.087	335.1	83.7
Red Decorative	5.5	0.019	0.015	0.041	12.7	3.2
White Decorative	8.6	0.029	0.025	0.076	24.0	6.0
Copper ore	1.1	0.004	0.003	0.009	2.9	0.7
Copper Concentrate	1.3	0.005	0.004	0.010	3.4	0.8
Iron ore	16.5	0.071	0.044	0.114	36.7	9.1
Silver ore	26.2	0.079	0.074	0.221	68.2	17.0
Gold ore	1.1	0.004	0.003	0.008	2.4	0.6

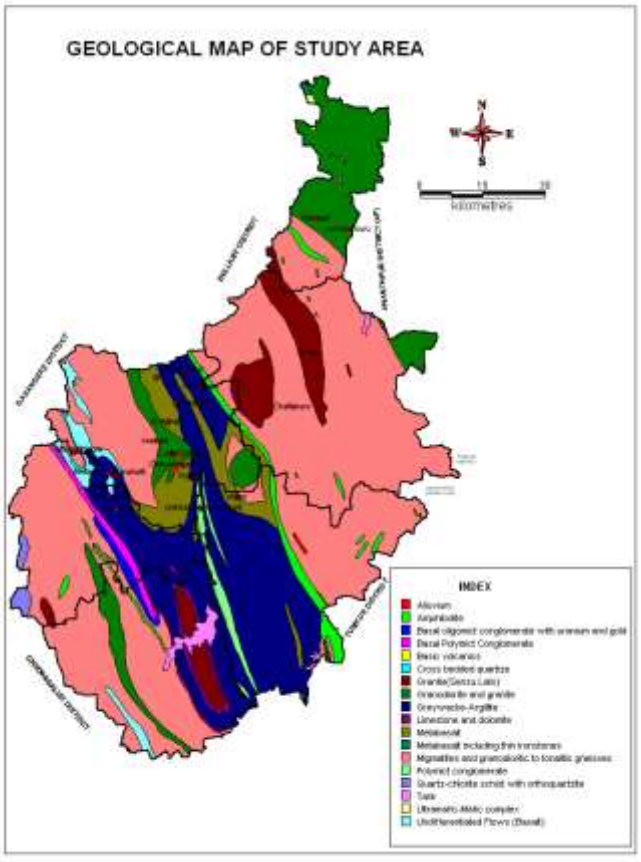

Fig. 1 Geological Map of Chitradurga

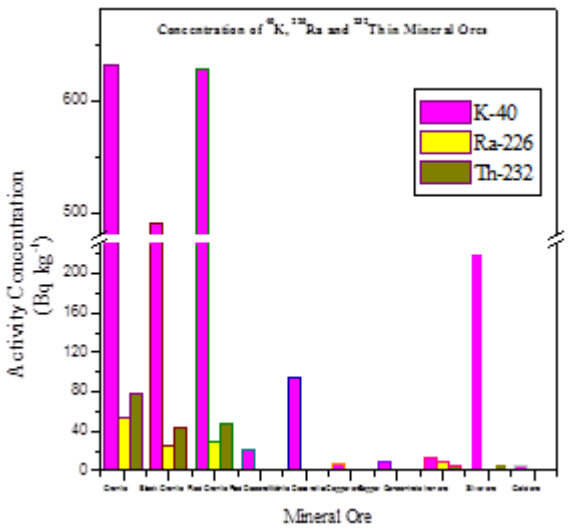

Fig. 2 Concentration of Radionuclides in Granites, Decorative Stones and Mineral Ores

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